Symbol Store: Sharing Map Symbols for Emergency Management

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Abstract

Maps are a primary means for supporting information sharing and collaboration in emergency management and crisis situations. While a variety of formalized map symbol standards for emergency contexts exist, they have not been widely adopted by mapmakers. Informal symbol conventions are commonly used within emergency management stakeholder groups, but until now there has not been a flexible mechanism for discovering, sharing, and previewing these symbol sets among mapmakers. In this paper we describe the design and development of the Symbol Store, a visually-enabled, web-based interactive tool intended to help mapmakers share point symbols. The Symbol Store allows users to browse symbols by keyword, category tags, and contributors. It also allows for symbols to be previewed on realistic maps prior to download. An initial prototype of the Symbol Store was evaluated by flood mapping experts from the State of California, and the results of this user study led to multiple refinements now implemented in the public version of Symbol Store located at www.symbolstore.org.

Keywords: map symbology, emergency management, web applications, standards

1 Introduction

Maps offer a critical form of communication and function as important analytical tools for distributing information in emergencies when it becomes necessary for stakeholders to develop a common operational picture (COP). Maps are also essential in other phases of emergency management that include preparedness, recovery, and mitigation activities. During emergencies, all tasks are time sensitive, and the speed with which one can read and interpret a map can signal the difference between lives and property saved or lost. Supporting rapid and efficient consumption of geographic data can be significantly assisted by having map design and symbology standards that users can learn and apply in advance of an emergency event. Additionally, when teams of collaborators from different organizations

come together in an emergency operations center (EOC), they can quickly learn how to read and interpret maps by learning from an existing map design and symbol standard.

This paper describes the design, development, and initial evaluation of a new, web-based mechanism for searching for and retrieving point symbols to support digital cartography. We present a novel system called the Symbol Store, based on a long-term, iterative study of mapmakers' symbol needs at the U.S. Department of Homeland Security (DHS) (see previous work in Robinson, Roth et al. 2010; Robinson, Roth et al. 2011; Robinson, Roth et al. 2012). The Symbol Store can help aid interoperability in emergency management situations where multiple local, state, and federal authorities collaborate on the development of a wide range of mapping products to develop situational awareness and marshal resources. Emergency management mapping tasks frequently include pre-disaster planning activities and strategic recovery efforts which can also stand to benefit from mechanisms that improve symbol interoperability. Currently, there are few elegant or efficient means for such stakeholders to access and share each other's methods for representing features on maps.

In the following sections, we describe relevant prior work on symbol standardization and previous means for sharing map symbology. Then we describe the key design goals and features of the Symbol Store. This is followed by a section describing an initial user evaluation conducted with flood mapping experts to test core features of the Symbol Store. Finally, we conclude with planned next steps to further refine and exploit the unique capabilities of the Symbol Store.

2 Background

Our focus in this research is on sharing point symbols for maps. While line and polygon features are also quite important, we have focused on symbol interoperability first with respect to point features, which are among the most common types of symbols used in emergency management tasks. These tasks can include disaster mitigation and response planning activities, as well as direct response and situational assessment mapping in the immediate aftermath of a disaster (Cutter 2003). They can also include long-term planning and remediation mapping efforts as communities engage in recovery efforts. As we discuss below, the majority of existing symbol standards focus on point symbols entirely or in large part. In addition, funding support for this research from DHS was directed specifically toward the task of exploring point symbol interoperability since it represents their most pressing area of need.

Two primary influences for our work include past efforts to develop map symbol standards and existing approaches for sharing map symbols.

2.1 Symbol Standards

In recent decades there have been a wide range of symbol standardization efforts that have resulted in the design and dissemination of point symbol references for use in common mapping contexts. These efforts include the development of the U.S. Military Standard MIL-STD-2525 (Dept. of Defense 2008), which prescribes a set of representations and modifiers to support map interoperability in military planning and combat situations. As a result of its adoption by NATO, this standard is used and modified by other stakeholders as well in a wide range of countries and contexts. For example, NATO countries

frequently support humanitarian relief missions with military-led assistance, and non-governmental agencies engaged in relief efforts will often make use of the same symbology to ensure interoperability.

Symbol standards for non-military purposes include the U.S. ANSI INCITS 41-2006 (ANSI 2006) Homeland Security Mapping Standard which prescribes a set of point symbols, symbol outlines, and graphical modifiers to support emergency management interoperability. The ANSI set was designed to function as a single standard used by local, state, and federal stakeholders in U.S. domestic emergency management situations. Despite concerted efforts to develop the ANSI standard for point-symbol symbology for exclusive use across DHS and with DHS partners (Dymon 2003; Dymon and Mbobi 2005), the standard has not achieved widespread adoption within DHS, or outside DHS in commercial tools like WebEOC (www.esi911.com) that are commonly used by state and local emergency management organizations. In previous research, we found that DHS mapmakers had symbolization needs that were unmet by the ANSI set, that many ANSI symbols were too graphically intricate to use in many situations, and that task-specific (but non-official) symbol sets already existed that were more commonly used to support emergency management mapmaking (Robinson, Roth et al. 2011). Furthermore, recent usability and utility evaluation of these symbols revealed that they have serious weaknesses when they are used to support emergency management tasks (Akella 2009).

Other symbol standards exist for emergency mapping and related contexts, including an international standard for humanitarian demining symbols (Kostelnick, Dobson et al. 2008) and a recent homeland security symbol standardization project in Canada (Sondheim, Charmley et al. 2010), which led to the development of a web repository (www.EMSymbology.org) where those symbols could be downloaded. Despite the availability of these official and many non-official but widely utilized symbol sets (such as those included with common GIS software packages) no single symbol standard has been widely adopted for general use across the full range of emergency situations in the United States or elsewhere.

One potential reason for lack of widespread adoption of symbol standards is that their development tends to receive a great deal of attention and resources, while their dissemination, implementation, and revision does not. Emerging needs for new and modified representations are not easily met through official standardization processes. In discussing the need for symbol standardization in the 1970's, Arthur Robinson suggested that while standards are necessary and useful, they must remain open-ended so that evolution can occur as mapping requirements change (Robinson 1973). New efforts to design symbols by MapBox (www.mapbox.com/maki) and the Noun Project (www.thenounproject.com) are responding to evolutionary needs to develop simple point-of-interest symbols for web maps for the former project, and to develop a common visual language to cross language barriers for the latter. The Map Icons Collection (www.mapicons.nicolasmollet.com) allows users to contribute point symbol designs for use in Google Map mashups. New approaches for supporting symbol sharing and interoperability need to be flexible enough to support new symbol sets like these and integrate them with existing methods to ensure the best representations are used for any given mapping context.

2.2 Current Methods for Sharing Symbols

Map symbols are most commonly shared today via digital means through common GIS software packages. While mapmakers are always able to create their own symbols, the default palettes available

in GIS software see wide adoption, although the original meaning of a particular symbol may be ignored in part or whole as mapmakers reinterpret symbols for use in new representational contexts (Robinson, Roth et al. 2011). In terms of their formal implementation, outside of the MIL-STD-2525 example noted above, where military units require its use and mapmakers as well as map readers are trained to use the standard, the other standards we reviewed may have formal endorsement but no firm requirements for mapmakers to actually use them.

In terms of tools for sharing symbols, Esri's ArcGIS supports the use of *.style files which can catalog and describe the representations used on maps in ArcGIS. We found when studying the use of ANSI symbols and other symbology at DHS that DHS mapmakers frequently made use of *.style files to curate their own task-specific (but not official) symbol collections, and in some cases would share these with other mapmakers. Recent development by the makers of Ortelius, a cartography software package for use in Apple iOS, includes the ability to share Ortelius-compatible map symbols online via a dedicated symbol management tool (Saligoe-Simmel 2010). Most officially-sanctioned map symbol standards are disseminated by government websites and shared in Esri-compatible formats. Our work with mapmakers at DHS indicated that the primary means for discovering symbols was by using web search engines to find new *.style files and fonts that include symbol markers.

We began our work on map symbology for emergency management in 2009 by researching the use and adoption of the ANSI symbol standard, identifying other symbols in use, and developing key user requirements for map symbology standards (Robinson, Roth et al. 2011) at DHS. We followed this work with the development and evaluation of a new, more flexible and iterative process for creating map symbol standards for DHS (Robinson, Roth et al. 2012). A primary result discovered through this prior research was the need for a new platform and model for supporting symbol interoperability. While current tools like ArcGIS and Ortelius allow users to share pre-defined symbol sets using Esri *.style files or other special formats, and web repositories like the Noun Project and EMSymbology.org exist for individual symbol sets there remains a need for flexible, visually-enabled tools to support dynamic symbol sharing and discovery. We believe the next step involves moving beyond simply retrieving symbols via the web, to support users who wish to contribute symbols to an evolving repository, to support users who want to search for appropriate symbols using keywords and other metadata (something not supported on sites like www.EMSymbology.org for example), to preview symbols on realistic maps, and to allow communities of mapmakers to iteratively rate and refine symbol collections to create new *de facto* map symbol standards. To fill this gap, we have developed the web-based Symbol Store to provide a usable and useful tool for contributing, browsing, rating and assembling customized symbol palettes to support mapmakers at DHS and beyond. The following sections describe our progress so far in meeting that goal.

3 Symbol Store

To support map symbol interoperability we have designed a web-based prototype tool for discovering, sharing, and retrieving map symbols called the Symbol Store. The following sections describe Symbol Store's core design objectives, its technical underpinnings, our demonstrated progress toward

implementing a working prototype, and the results of a user evaluation to test the first working prototype to suggest future refinements.

3.1 Design Objectives

Based on the results of our prior work to study the utility of the ANSI standard for DHS mapmakers and to design a new process to developing more flexible symbol standards, we developed four core system functionality targets for shaping the design of our first Symbol Store prototype:

Search for and retrieve symbols

The most basic design goal for Symbol Store is to support keyword searches for symbols in use by agencies across DHS (and potentially wider audiences as the tool becomes open to other groups as well). Symbols retrieved via keyword search can be collected and downloaded as an ESRI *.style file or in other common formats for immediate application.

Preview symbols on realistic maps

After selecting a subset of symbols from the Symbol Store search interface, users can preview their symbols on a variety of realistic basemaps. The map preview feature in Symbol Store provides a range of basic design controls to allow users to change the map scale, feature density, labeling, coloring, and other common map design aspects in order to preview the suitability of their symbols prior to downloading them.

Browse for symbols

Apart from searching for specific symbols, users can browse symbols by time (most recent uploads, for example), contributor (symbols from a specific agency, for example), and symbol categories (all symbols corresponding to infrastructure, for example). This supports flexible means for discovery, for instances in which keyword searches are not as efficient or effective. It also allows popularity measures such as subjective ratings to become one of the means through which new symbols can be discovered and disseminated.

Share symbols

Users can contribute symbols to Symbol Store by uploading an Esri *.style file and associated fonts through the Symbol Store interface. After uploading symbols, users are able to tag individual symbols or groups of symbols to assign keywords, category names, and other important metadata information.

3.2 System Architecture

To accomplish our design objectives we designed an interactive web interface to encourage use by a wide range of users across multiple platforms. Simple and effective interoperability is essential to support DHS users coming from a diverse set of organizations, and to ensure more widespread adoption of formal standards by other related emergency management communities in the longer term.

The Symbol Store interface runs in a standard web browser using the Adobe Flash plugin. The interface itself was constructed using Adobe Flash Catalyst, an interface development environment that integrates with Adobe Flex, which we used to connect the Symbol Store interface to server-side components. Symbol Store is comprised of four main components, illustrated in Figure 2 and includes: 1) the Flex and ActionScript User Interface (UI); 2) the .NET CSharp web service middleware; 3) the storage system of an Apache Lucene Index (apache.lucene.org) and a SQL Server Relational Database Management System (DB); 4) and an instance of Esri ArcGIS Server to produce live, interactive map previews with selected symbols.

A Lucene index is used to store the text metadata about symbols in the Symbol Store, including Symbol name, symbol description, keywords, user, symbol set, and other features. This allows for text searches to be performed when searching for information. When a text based search is performed, the Lucene index is queried and pointers to the symbols are returned. Next the DB is queried to retrieve those symbols that matched the Lucene index query. Users are then able to create a customized symbol set by selecting individual symbols, adding them to their symbol cart and downloading the newly created style file containing the symbols.

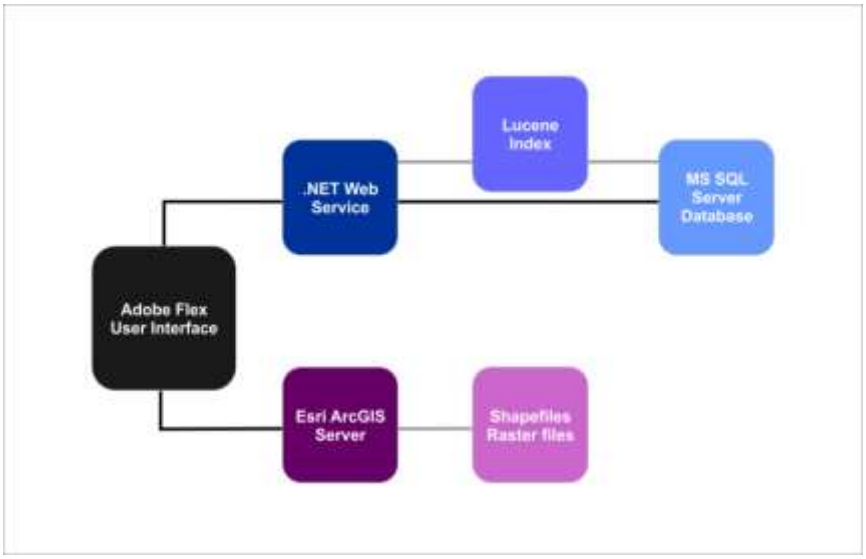

Figure 1: Architecture of Symbol Store. Symbols with metadata (e.g. keywords, set, categories, date of upload, ratings) are stored in a database and indexed using the Lucene Index. Map previews are stored and served using ESRI's ArcGIS Server 10.

In addition to obtaining symbols to match their needs, users can contribute symbols to the store by uploading either Esri *.style files or TrueType font files. When these files are uploaded, symbols are stored in a SQL Server Database table record and an image thumbnail of the symbol is created using Esri's ArcObjects tools. Once symbols have been uploaded to the system and stored in the database, the user is presented with a metadata editing interface where they have the option to add metadata for the symbol collection as a whole and/or for individual symbols. Symbols are easily retrieved through an SQL query when the user decides to download symbols from their symbol cart.

The final component of the Symbol Store allows for the preview of symbols on a map. The Symbol Store map preview tool allows users to preview the symbols that they have placed in their shopping cart. The map preview has been crafted to allow users to choose a base map style and scale, and then adjust many of the symbol properties, such as size, density, and labeling. This allows users to compare different potential symbol sets and choose the set that is the most legible given their choice in cartographic design. Three main control types have been designed to support on-the-fly visualization of symbol properties. The base map type can be chosen using a button feature. Horizontal sliders are used to adjust for symbol size, map scale, point density, and label size. Finally, a user's choice in labeling or not labeling the features uses a checkbox control.

The base map is comprised of several ArcGIS shapefiles representing transportation, political boundaries, and water bodies. The features were acquired from the U.S. National Atlas for national and regional scales, and several state-level agencies for the State, County, and City level data. For state-level data, we chose Washington State as the example, and have used data from the Washington Department of Transportation, the Washington Department of Environmental Quality, and King County's GIS Center. To display map point symbols, we have created several levels of point density for each of the scales by generating random point symbols.

3.3 Symbol Store prototype features

The initial Symbol Store prototype underwent multiple rounds of internal evaluation and refinement to satisfy our stated goals to support symbol search and retrieval, symbol browsing, symbol sharing, and preview symbols on realistic maps.

The initial prototype Symbol Store search interface is shown in Figure 2**.** Each symbol includes metadata to show its description, a list of relevant keywords, relevant thematic categories, membership in a formal symbol standard (e.g. ANSI), users of this symbol (e.g. different divisions within DHS), contact information for the person responsible for uploading the symbol, and the date the symbol was uploaded. Users can select symbols for download or preview by adding them to the cart shown on the right of the screen in Figure 2. Once users are satisfied with the selected set of symbols, they can prepare and download the set as an Esri *.style file.

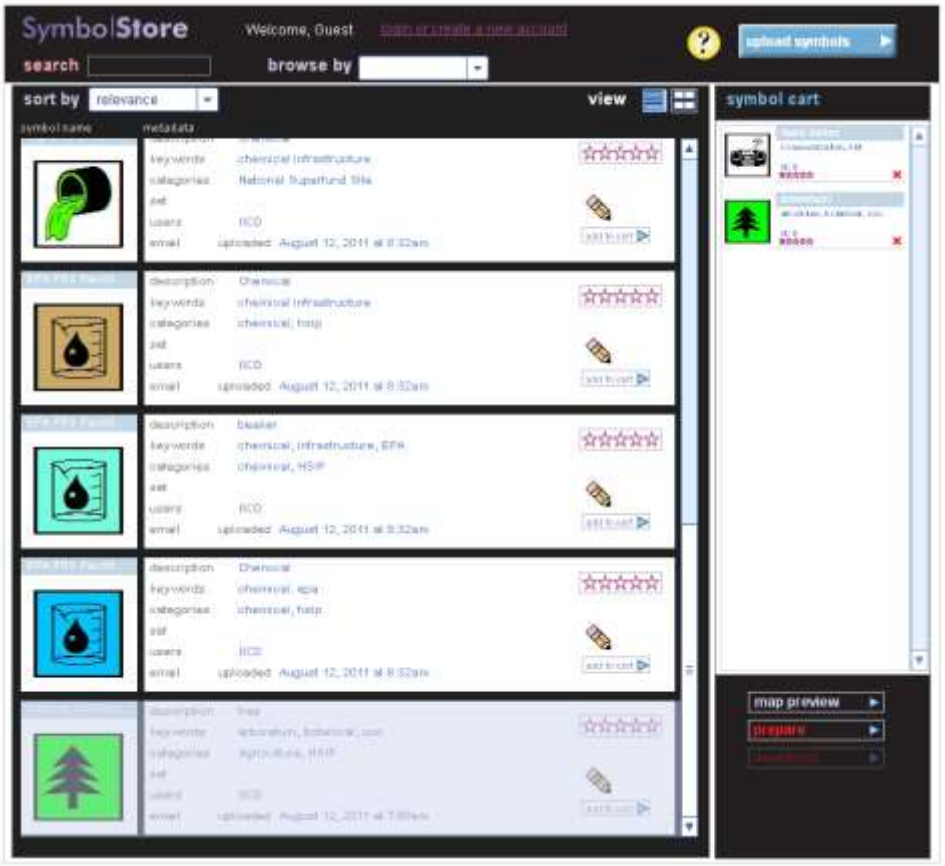

Figure 2: This screen capture shows the initial prototype Symbol Store interface with symbols contributed from IICD.

Symbols can be easily contributed to the initial prototype Symbol Store by way of a specialized upload and metadata creation interface we have implemented (Figure 3). Users can select an Esri *.style file and associated font files and upload these to the Symbol Store database. Once the Symbol Store has processed these files, a secondary interface appears (shown at the bottom of Figure 3) so that users can add metadata to the contributed symbols. For the entire collection, users can edit the contributing agency, assign symbol categories associated with the set, identify the username of the person contributing the set, and name the official symbol standard to which the symbols belong (if applicable). For individual symbols (or smaller groups of multiple symbols, selected by clicking checkboxes in the metadata editing interface), users can add descriptions, keywords, categories, users (such as agencies or departments), and ratings (from 1 star to 5 stars). Users can also edit symbol metadata once the symbols have been published in the Symbol Store.

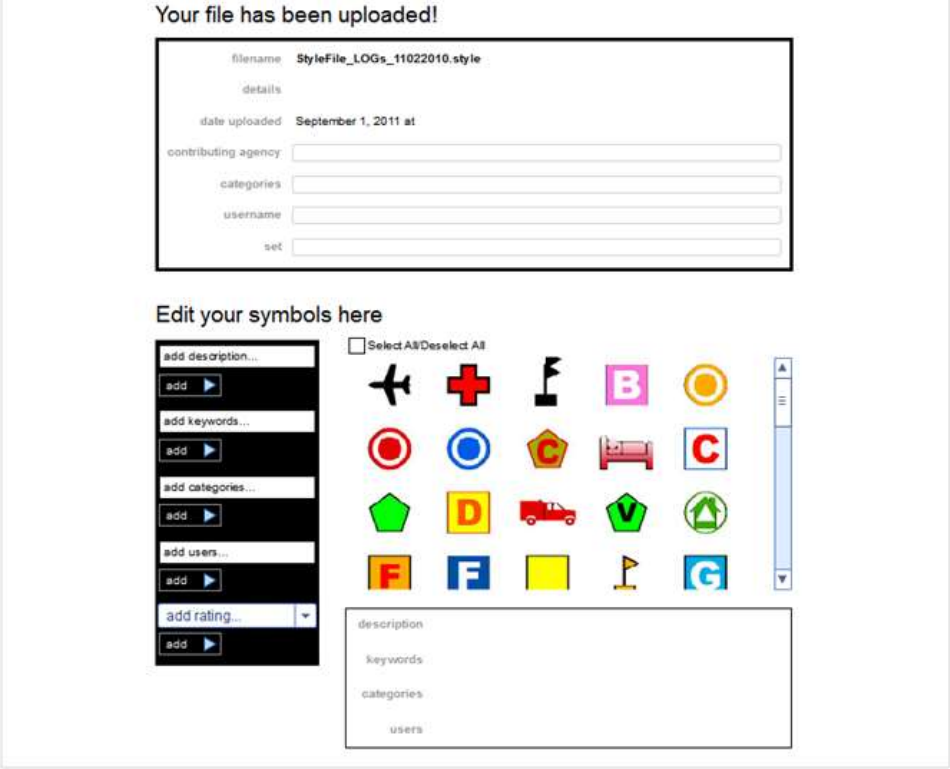

Figure 3: The Symbol Store symbol upload and metadata editing interface.

The map preview feature (Figure 4), inspired by popular web tools for cartographic design like ColorBrewer (Harrower 2003) and TypeBrewer (Sheesley 2007), which provide example maps to help users choose among design options, will allow users to visually evaluate the symbols that are currently in their symbol cart in a realistic map design context. The map preview tool in Symbol Store allows users to change the type of map background between common basemap options, to change the color of the basemap between color or black and white, and to adjust symbol sizes, the map scale, feature density, and labeling. These common design parameters are adjustable interactively to help users rapidly evaluate the symbols they have chosen against a variety of realistic map design constraints. One goal here is to decrease the amount of time mapmakers spend creating multiple design iterations to develop a particular map.

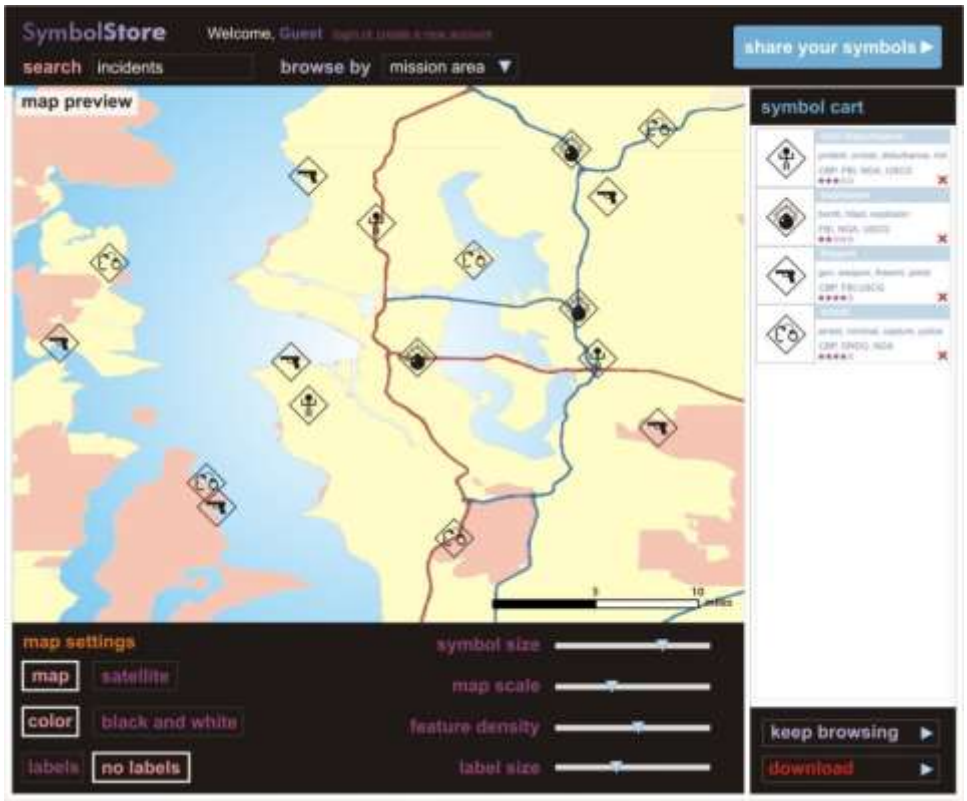

Figure 4: The map preview function (shown here in a design mockup) in the Symbol Store allows users to select from different map types and to control other symbol and map design attributes to preview symbols placed in the symbol cart.

4 Evaluation

In addition to multiple rounds of internal refinement of the Symbol Store prototype, including substantial informal feedback from DHS stakeholders in monthly project meetings, we have completed an initial formative user evaluation to inform our next steps.

We recruited six mapmakers from California's Department of Water Resources (DWR) who regularly engage in emergency management mapping centered on floods and other water-related emergency events. DWR staff are also engaged in an effort to develop an internal standard for symbology, so this user group would potentially benefit from a tool like the Symbol Store when identifying candidate symbols from other sets. Our goals in this study were to evaluate the utility of the Symbol Store for daily DWR mapmaking needs, to help develop their own standard set of symbols, and to characterize how well the Symbol Store could support symbol sharing for DWR once they have created a standard that could be shared.

4.1 Evaluation Procedures

Our evaluation activities were composed of a task analysis to test key functions in the Symbol Store and an online survey to capture and elicit user feedback. We developed six tasks for DWR mapmakers to complete. In general terms, the six tasks included; uploading symbols, searching for symbols, selecting

symbols to preview, previewing symbols on realistic maps, downloading symbols, and testing a downloaded Esri *.style file. After completing these tasks with the Symbol Store prototype, users were asked to rate the usability and utility of the Symbol Store in an online survey. Many of the survey questions also prompted users to provide qualitative feedback to elaborate upon their opinions and suggest specific new features or bugs to fix.

This user study was aimed at formative assessment (Buttenfield 1999) of the Symbol Store prototype in order to establish which steps to take going forward to add/remove key features and to develop a baseline understanding of the tool's usability.

4.2 Task Analysis Results

The following sections describe each of the six tasks our study participants completed and discuss survey feedback gained from questions related to each task. All survey questions aside from two multiple choice prompts used a five-point agreement scale; strongly disagree – 1, disagree – 2, neither agree nor disagree – 3, agree – 4, and strongly agree – 5. Average ratings are used in the following sections according to this scale to note participant agreement level with prompts about the usability and utility of features and functions in the Symbol Store (Figure 5). All questions were crafted in a manner to allow participants to agree or disagree with the premise of the prompt. A reference document showing the full task descriptions as well as the complete set of survey questions is available in Appendix A (www.personal.psu.edu/acr181/SymbolStore_Appendix_A.pdf).

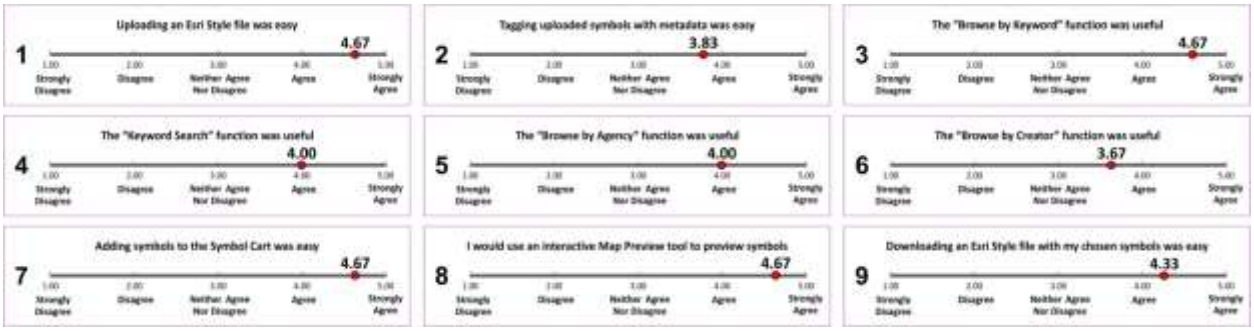

Figure 5: User rating results for key aspects of Symbol Store usability and utility.

4.2.1 Task One: Upload Symbols

Participants were asked to upload an Esri *.style file containing eight point symbols and to create metadata for those symbols by tagging them with keywords, categories, and other relevant source information. When asked to rate how easy it was to upload a .style file, the average of user ratings was 4.67 (Q1 in Figure 5) on the five-point agreement scale described above, indicating that users found this task easy to accomplish.

While participants generally agreed that the process of adding metadata to their symbols was easy (3.83 rating – Q2 in Figure 5), many suggestions on how to improve this part of the interface were offered. The names assigned to each symbol were not visible during the tagging process which led to much confusion over what each symbol was intended to be used for. Also, the text fields intended to contain

the keywords and categories were not large enough. Other comments mentioned the need to apply changes in metadata to multiple symbols at one time (when assigning category names, for example).

4.2.2 Task Two: Search for Symbols

In the second task, participants were asked to search for the symbols to which they had just added metadata via both keyword search and basic browsing methods. In addition to typing search terms into the keyword search box, participants used the "Browse By" option to select from a list of categories and keywords, and they could also search by clicking on keywords associated with a symbol in the symbol list itself. Additionally, during this task, participants were given the option to update or change metadata they had previously entered for any given symbol. Our users found the "Browse By" option to explore existing keywords most useful (4.67 rating), followed by traditional keyword search (4.0 rating). Browsing by agency (4.0 rating) and creator (3.67 rating) metadata was also judged to be useful (Q3 –Q6 in Figure 5).

Qualitative feedback from this task revealed that the most common concern with the search and browse options was there was no obvious way to clear a search and return to a previous view. Additionally, there was no way to show an overview of all symbols. Some study participants also found a bug that caused keywords and categories in the list to appear without associated symbols. A small interface design issue regarding the size of the symbol name was also highlighted by several users.

4.2.3 Task Three: Select Symbols to Preview

In the third task, participants were asked to select approximately a dozen symbols and add them to their Symbol Cart to preview prior to download. This was a very simple task that required clicking icons on symbols of interest to add it to a "shopping cart" style interface. This feature's usability received strong support (4.67 rating, Q7 in Figure 5) and none of the participants provided comments or suggestions to improve this part of the interface.

4.2.4 Task Four: Preview Symbols

Our intention for the fourth task was to have participants evaluate the map preview feature to self-assess a set of symbols added to the symbol cart. The development work to enable this feature was not completed in time for the user study, and instead our participants were given a mockup preview screen (shown in Figure 4) and asked to comment on the likelihood that they would use such a tool (4.67 rating, Q8 in Figure 5), and to rate the relative importance of each proposed map preview function.

Participants were unanimously in favor of all of the proposed functions suggested by the mockup concept. One specific additional suggestion was offered during the focus group discussion, which is to add the option to preview their symbols over a USGS Topographic basemap.

4.2.5 Task Five: Download Symbols

Once study participants had chosen their symbols they were asked to download them. The evaluated prototype supported downloads using an Esri *.style file, which is one of several common means for formalizing the look of a digital map product. This task was very straightforward and widely viewed as easy (4.33 rating, Q9 in Figure 5) and the only suggestion from participants was to implement a way to combine the “Prepare” and “Download” steps to make downloading possible with a single click.

*4.2.6 Task Six: Test Downloaded *.style File*

The final task involved launching a new Esri ArcGIS project, adding the downloaded Esri *.style file to the map document and viewing the point symbols in the ArcGIS Style Manager or assigning those symbols to point features in the map document.

One study participant had trouble downloading the file on the first try (their subsequent attempt was successful), and another study participant found two of their chosen symbols did not download properly. The latter error is a known issue associated with having all of the necessary fonts installed locally where the *.style file is downloaded. A large proportion of symbols in Esri ArcGIS are drawn directly from custom fonts that use symbols in place of alphanumeric characters. The *.style file then connects to these fonts and draws them in specific ways based on chosen design attributes. In this case, the study participant was missing the font necessary to view two of their downloaded symbols. All other downloaded symbols worked properly for all of the study participants.

An improvement that can be made to the downloaded *.style file was suggested to incorporate the keywords associated with a symbol in the Symbol Store into the “tag” field associated with the *.style file so that those imported symbols can then be searched for using the ArcGIS symbol browsing tool. The evaluated Symbol Store prototype downloaded *.style file only contained the symbol name and Esri-software assigned default design attributes present when the symbol was originally uploaded to the Symbol Store. Study participants expressed concern that they spent a good deal of time adding keywords and metadata to symbols and then were not able to use that information once the *.style file was downloaded to their local machine.

4.3 Evaluation Summary

Our evaluation of the initial Symbol Store prototype with flood mapping users from the state of California yielded useful feedback on usability and utility. Approximately twenty small interface improvements were identified by the study participants, and a variety of major improvements were suggested:

- Implement the map preview as designed in the mockup
- Improve search behavior to retrieve additional relevant results beyond exact matching keywords
- Improve the interface look and feel to make functionality easier to find and visually distinct from search results
- Support a wider range of export formats to avoid problems with fonts
- Use tabbed pages to view symbol results incrementally

- Add a USGS topographic basemap option to the map preview tool
- Develop a grid view to show a larger overview of available symbols when browsing
- Support import and retrieval of line and polygon symbols
- Implement user accounts so that draft symbol standards can be shared among a working group before being released to a wider audience
- Import/export more metadata when contributing or downloading *.style files

Overall, our evaluation results with this small group of real-world users demonstrate the potential of a tool like the Symbol Store to support usable and useful symbol discovery, retrieval, and contribution. User feedback after the survey indicated that our participants were eager to see future revisions to the prototype and for the tool to be robust enough to support regular, widespread use in their agency.

5 SymbolStore.org

Following the results of our initial evaluation with flood mapping users in California, we implemented many of their suggested changes and began transitioning the prototype Symbol Store to a public-facing site for widespread use. The Symbol Store is now available at www.symbolstore.org, and currently hosts over 2400 symbols that can be easily discovered, previewed on realistic maps, and downloaded in a variety of useful formats. Some of the major improvements made from the evaluated prototype include; a fully-functioning map preview tool, a redesigned user interface to improve clarity and offer a standardized look and feel, pagination of search results to improve usability, and two new export formats (PNG and SVG) to avoid problems with sharing fonts and improve interoperability.

The improved primary interface is shown in Figure 6. In addition to the major improvements already listed, we fixed the bug that caused keywords and categories to appear that did not link to search results, and we have improved connections to Lucene to support more flexible search behavior to retrieve more results with single keywords. For example, a search for “fire” will now return anything that includes the stem of that term, so “firing range” will appear as a result rather than only exact matches for “fire.”

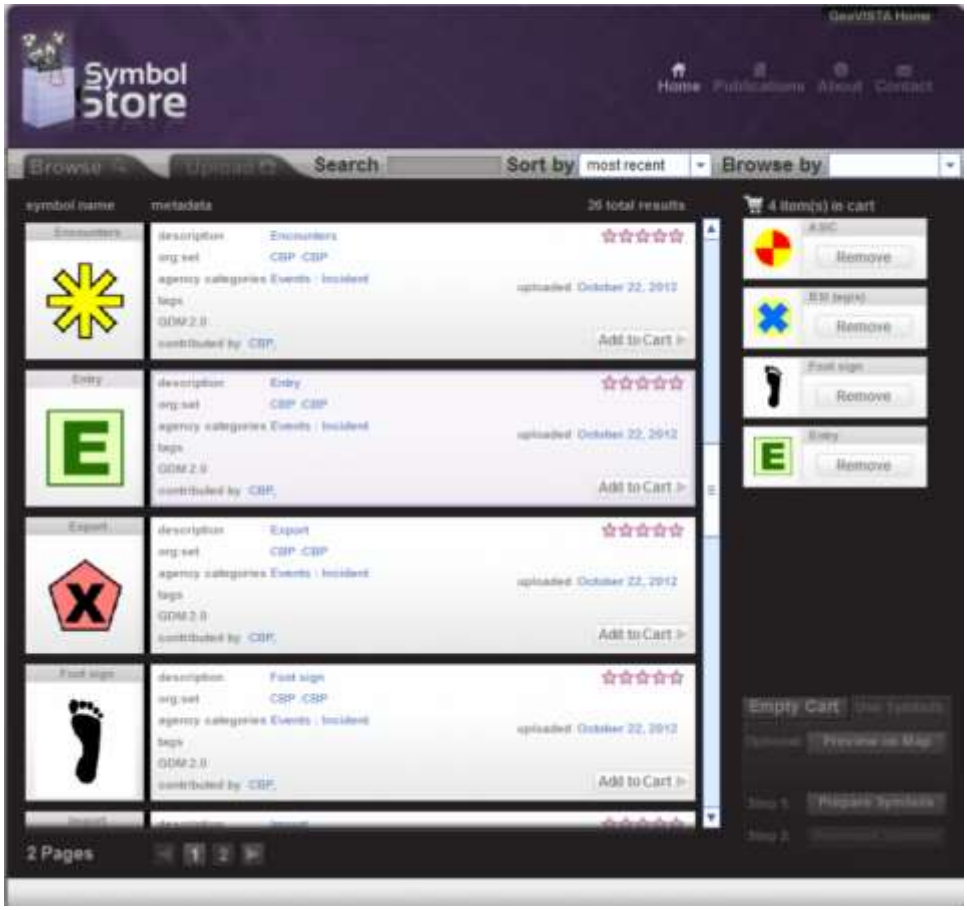

Figure 6: The redesigned Symbol Store interface is now available for public use at www.symbolstore.org.

The map preview tool (Figure 7) now allows users to interactively assess the symbols in their symbol cart using a range of common map design controls to change the basemap design, alter the size/density of symbols on the map, and explore the symbols when used at three common scales. The map preview tool leverages ArcGIS Server to generate and manipulate real-time map previews on the web client.

Figure 7: The map preview function of the Symbol Store is now fully-functioning and allows users to visually evaluate symbols prior to download.

A major step toward supporting wider symbol interoperability is the inclusion of new symbol formats with every Symbol Store download. Users now can retrieve a single .zip file archive which includes PNG symbols at a range of useful icon sizes, an Esri *.style file, and SVG vector graphics for use in graphic design software. SVG symbol export is made possible by tracing PNG images of symbols using an automated back-end routine that leverages the Inkscape open source graphic design software (www.inkscape.org).

Symbol contributions are supported in the public www.symbolstore.org site through a new, simplified interface shown in Figure 8. Currently, we do not allow public contributions to be processed and appear automatically to prevent potential abuse, and we are exploring ways to support metadata creation and editing for public users while ensuring that contribution quality will remain high.

Figure 8: Public contributions of symbols to the Symbol Store can make use of the new, simplified uploader shown here.

6 Conclusions and Future Work

Following our initial evaluation and refinement effort, we will focus on collecting feedback on the second-generation prototype available at www.symbolstore.org from DHS mapmakers through a series of planned practitioner workshops. In these workshops, DHS users will complete realistic symbol-related tasks using the Symbol Store and we will engage these users in group discussions to identify next steps for Symbol Store development and integration into existing DHS work practices. We anticipate that the Symbol Store will be useful for a wide range of emergency management related tasks, including pre-emergency planning, post-disaster situational assessment mapping, and long-term recovery efforts. In terms of its immediate utility during the response phase of an emergency, we would anticipate that the Symbol Store would be a quicker way to discover, download, and use symbols than their current affordances, which rely on manual web searches and informal relationships with other mapmakers (Robinson, Roth et al. 2011) allow.

A key focus for Symbol Store development going forward will be on integrating what we have learned from symbol standard development through the standardization process we developed and the e-Symbology Portal tools we used to conduct process tests with CBP, FEMA, and IICD (Robinson, Roth et al. 2012). We will develop methods and techniques to move components from our standardization process into the Symbol Store interface to combine the two efforts in an elegant and effective unified environment. A key goal is to provide access to more sophisticated metadata and category standardization tools and procedures for small groups of motivated users and symbol set curators. These higher-level functions will require accounts and log-in permissions so as not to interfere with basic use by members of the public and mapmakers who simply want to quickly find and retrieve symbols.

Other challenges for future development include new methods to expand searches to return relevant results. One strategy we are currently implementing is to leverage WordNet (Miller 1995) measures of similarity between words in the English language to find relevant terms beyond an initial keyword and

retrieve a wider set of relevant symbols to the user. Searching for symbols by visual similarity also remains an important, but difficult to achieve goal. Ideally, cartographers should be able to find “more like this” when viewing a particular symbol. Along those lines, it may be possible for us to develop a mechanism to crawl the web to automatically collect symbols that already exist in a wide range of formal and informal repositories.

Additionally, many issues exist when it comes to how users define, assign, and interpret categories of symbols, and definitions associated with specific symbols. Multiple examples of the same graphical symbol carrying different meanings have been noted in our prior work with DHS mapmakers (Robinson, Roth et al. 2011), and we remain in need of better strategies for highlighting such differences in search results in the Symbol Store to make users aware of different interpretations. Card-sorting and other methods for developing and evaluating categories associated with symbols (Roth, Finch et al. 2011) need to be adapted for individuals to use in web-based tools like the Symbol Store.

While supporting map interoperability involves challenges that extend well beyond the common and consistent representation of features using symbols, we believe our work to design and develop the Symbol Store contributes a novel web-based approach that has the potential to significantly help cartographers discover, retrieve, and share symbols beyond the means afforded by current GIS software and informal personal symbol collections.

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